This document contains Part 2 (pp.225–248) of Chapter 8 of the National Coastal Condition Report III.

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National Coastal Condition Report III

Chapter 8: Coastal Condition of Alaska, Hawaii, and the Island Territories

Part 2 of 2

December 2008

Hawaii

The overall condition of Hawaii's coastal waters is rated good based on two of the indices assessed by NCA (Figure 8-9). The water quality index is rated good, and the sediment quality index is rated good to fair. The NCA was unable to evaluate the benthic, coastal habitat, or fish tissue contaminants indices for Hawaii's coastal waters. Figure 8-10 provides a summary of the percentage of coastal area in good, fair, poor, or missing categories for each index and component indicator. This assessment is based on environmental stressor and response data collected by the NCA, in conjunction with state agencies, EPA Region 9, and the University of Hawaii, from 79 locations along the islands of the Hawaiian chain in 2002. Please refer to Chapter 1 for information about how these assessments were made, the criteria used to develop the rating for each index and component indicator, and limitations of the available data.

The Hawaiian Islands are the most isolated archipelago in the world. Hawaii's isolation has resulted in the highest percentage of endemic flora and fauna species anywhere in the world. However, this singular distinction has a downside: Hawaii has suffered the greatest number of known extinctions of fauna and flora during the past 200 years due to the development and westernization of the islands (Loope, 1998).

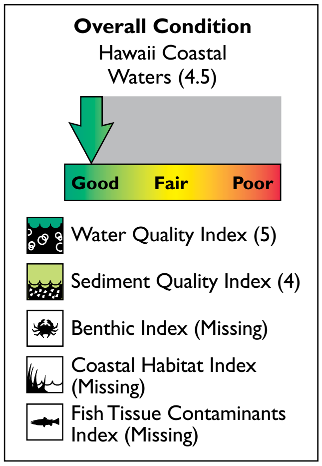


Figure 8-9. The overall condition of Hawaii's coastal waters is rated good (U.S. EPA/ NCA).

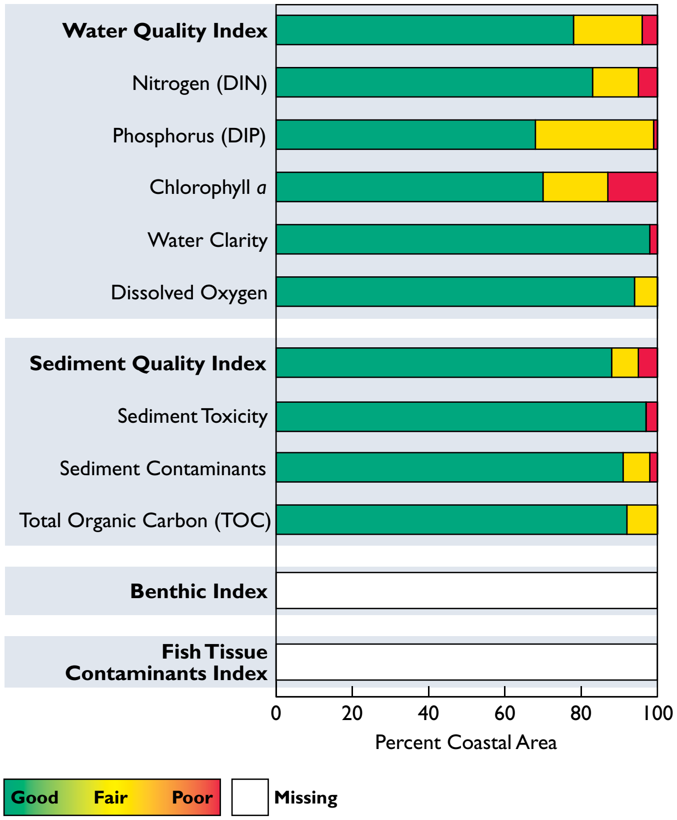


Figure 8-10. Percentage of coastal area achieving each ranking for all indices and components indicators—Hawaii (U.S. EPA/NCA).

Hawaiian monk seals are an endangered species that is native to Hawaii (courtesy of James Watt, DOI).

The human population of the Hawaiian Islands has fluctuated over time. Following contact with the West, disease took its toll on the islands' native population, and there were less than 60,000 individuals remaining on the islands by the 1870s. By 1900, the total population had grown to 154,000 people, primarily through the importation of labor for agriculture. Figure 8-11 shows that the population of Hawaiian coastal counties increased by 0.3 million people (30%) between 1980 and 2003 (Crossett et al., 2004). As of 2004, Hawaii's population exceeded 1.2 million people, and more than 90% of residents lived in urban centers (U.S. Census Bureau, 2006a).

Human development, increases in population, and economic growth have all exacerbated the impacts to native ecosystems because of the relatively small land area of the Hawaiian Islands. Sedimentation problems associated with land-use changes may be especially acute in the coastal areas of Hawaii because of the combination of steeply sloped coastal watersheds, high seasonal rainfall, and agricultural and other land development (Cox and Gordon, 1970; Meier et al., 1993). Human population growth in Hawaii is a principal driver for many ecological stressors (e.g., habitat loss, pollution, nutrient enhancement), which may alter coastal ecosystems and affect the sustainability of coastal ecological resources. Increased globalization of the economy is a major driver influencing the introduction of exotic species into Hawaiian ports and harbors.

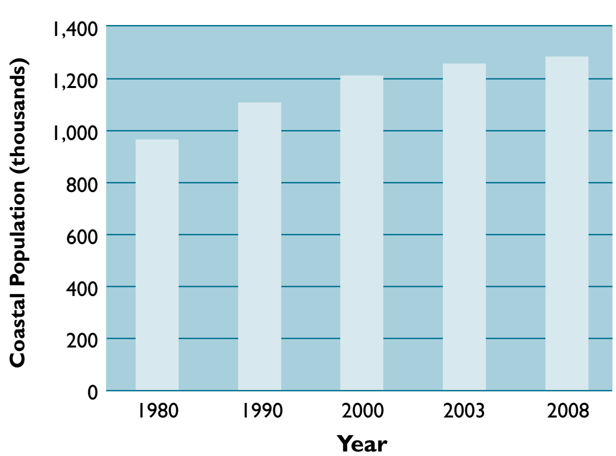


Figure 8-11. Actual and estimated population of the Hawaiian Islands from 1980–2008 (Crossett et al., 2004).

Compared to other regions considered in the NCCR III, estuaries and coastal embayments are a small, but ecologically significant, component of Hawaii's coastal resources. These coastal waters represent less than 1% of the coastal ocean area around the Hawaiian Islands and are best developed on the older islands (Kauai and Oahu). Pearl Harbor, which is the largest remaining Hawaiian estuary, has a water surface area of approximately 22 mi^2 and is one of the country's largest naval ports. However, most of Hawaii's estuaries and coastal embayments are small, occupying less than half a square mile. Historically, these coastal waters were more significant than they are today. In the Moiliili-Waikiki-Kewalo districts of Honolulu on Oahu, approximately 48% of the land area was occupied by wetland/estuarine habitat in 1887. Today, these aquatic features are absent, and the remaining estuarine waters are channelized conduits that rapidly transport stormwater runoff to the sea (Cox and Gordon, 1970; Meier et al., 1993).

Estuaries and coastal embayments serve as important nursery habitat for a number of commercial and recreational Hawaiian fishery resources. These aquatic features also act as natural biological filters by sequestering sediments and pollutants adsorbed to particulate materials, thus lessening the impact of stormwater runoff on adjacent coral reefs. The development of the hinterland surrounding most of Hawaii's largest estuaries, combined with concurrent pollution and alien species introductions, have resulted in tremendous changes to the abundance and species composition of important coastal communities. Causal mechanisms responsible for these changes have not been quantitatively defined, and the rate of these changes has not been measured.

Coastal Monitoring Data—Status of Coastal Condition

The principal population and commercial center for the Hawaiian Islands is located on the south shore of Oahu in an area encompassing Pearl Harbor, the Port of Honolulu, and several other estuaries or embayments. These coastal systems are highly altered and surrounded by a high-density, urban setting. The rest of the Hawaiian Islands have a much lower population density. Although one might presume that the magnitude of anthropogenic impacts would be highest in the urbanized estuaries of Oahu, this hypothesis needs to be rigorously tested.

Hawaii does not yet have a comprehensive coastal monitoring program. Some monitoring occurs in Oahu and is planned for adjacent coral reef ecosystems; however, most coastal resource monitoring is targeted to address specific bays and/or issues, such as nonpoint-source runoff and offshore discharges. For example, Mamala Bay has been sampled intensively to examine WWTP outfalls from Oahu into the Bay. This sampling showed that the discharge areas were not statistically different from reference areas; however, data were lacking to interpret these findings in a statewide or regional context (Swartz et al., 2002). In 2002, the NCA, in conjunction with state agencies, EPA Region 9, and the University of Hawaii, conducted the first comprehensive survey of the coastal condition of Hawaii. The survey sampled 50 stations spread across the main islands and 29 stations concentrated along the south shore of Oahu within the urbanized estuaries, including Pearl Harbor and Honolulu Harbor. For this assessment, the coastal area assessed included semi-enclosed coastal embayments and true estuaries.

Water Quality Index

The water quality index for Hawaii's coastal waters is rated good. This index was developed based on measurements of five component indicators: DIN, DIP, chlorophyll *a,* water clarity, and dissolved oxygen. Most (78%) of the coastal area was rated good for water quality condition, 18% of the area was rated fair, and 4% of the area was rated poor (Figure 8-12). Most cases of fair condition were driven by elevated concentrations of DIP and chlorophyll *a*. The finding that 22% of the area has either poor or fair water quality should be considered preliminary. As described below, water clarity measurements were not obtained at many stations. Determination of an acceptable level for DIP concentrations may also require further consideration.

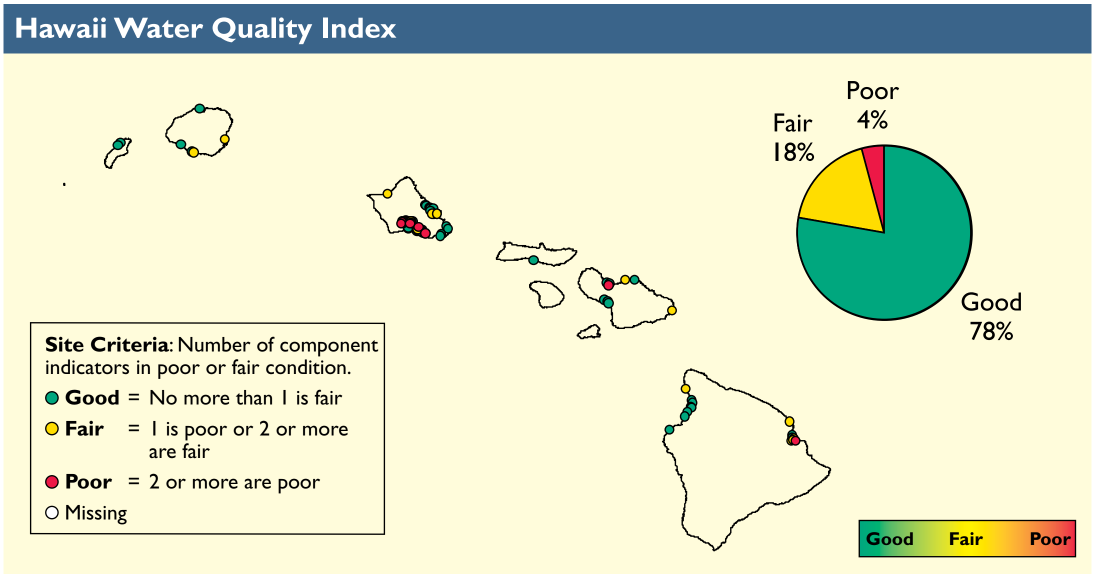


Figure 8-12. Water quality index data for Hawaii's coastal waters (U.S. EPA/NCA).

The sampling conducted in the EPA NCA survey has been designed to estimate the percent of coastal area (nationally or in a region) in varying conditions and is displayed as pie diagrams. Many of the figures in this report illustrate environmental measurements made at specific locations (colored dots on maps); however, these dots (color) represent the value of the index specifically at the time of sampling. Additional sampling would be required to define temporal variability and to confirm environmental condition at specific locations.

Nutrients: Nitrogen and Phosphorus

Hawaii's coastal waters are rated good for DIN concentrations, with only 5% of the coastal area rated poor and 12% rated fair for this component indicator. Sites with high nitrogen levels tended to be located in harbors or urban estuaries. For example, sites in the Ala Wai Canal in downtown Honolulu, Kahalui Harbor, and Hilo Bay exhibited elevated DIN concentrations.

Hawaii's coastal waters are also rated good for DIP concentrations, with 31% of the coastal area rated fair for this component indicator. Only 1% of the coastal area, representing one site in Pearl Harbor, received a poor rating for DIP concentrations.

Chlorophyll *a*

Hawaii's coastal waters are rated fair for chlorophyll *a* concentrations, with 13% of the coastal area rated poor and 17% rated fair for this component indicator. Approximately two-thirds of sites rated poor for chlorophyll *a* concentrations were located within the urbanized estuaries of Honolulu on the island of Oahu.

Water Clarity

Water clarity in Hawaii's coastal waters is rated good. Water clarity was rated poor at a sampling site if light penetration at 1 meter was less than 20% of surface illumination. Approximately 2% of the coastal area was rated poor for this component indicator, and 98% of the area was rated good. In Hawaii, estimates of water clarity were obtained using a Secchi disk. At more than half of the stations, the Secchi disk was still visible at the bottom, and a valid reading of Secchi depth for estimating water clarity could not be obtained; therefore, these estimates of water clarity have a high degree of uncertainty and should be considered preliminary. Given the situation of having the Secchi disk visible at the bottom, it is likely that the estimate of good condition for water clarity in these waters is conservative.

Dissolved Oxygen

Dissolved oxygen conditions in Hawaii's coastal waters are rated good, with only 6% of the area rated fair and none of the coastal area rated poor for this component indicator. The sites rated fair were located in Pearl Harbor (2 sites) and Keechi Lagoon. At each of these stations, the dissolved oxygen concentrations were just below 5 mg/L. Although conditions in Hawaii appear to be generally good for dissolved oxygen, measured values reflect daytime conditions, and some areas with restricted circulation may still experience hypoxic conditions at night.

Garden of Eden, Maui, HI (courtesy of Ben Fertig, IAN Network).

Sediment Quality Index

The sediment quality index for Hawaii's coastal waters is rated good to fair, with 7% of the coastal area rated fair and 5% of the area rated poor for sediment quality condition (Figure 8-13). The sediment quality index was calculated based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC. Poor sediment quality ratings were primarily a result of metal and organic contaminant concentrations in the urbanized estuaries on the south shore of Oahu. Amphipod toxicity at two sites (one on Oahu and one on Kauai) was the second-most important contributing factor to the areal estimate of poor condition. Sites rated fair for sediment condition were almost exclusively associated with elevated levels of sediment contaminants, primarily metals and individual PAHs, within the ports, harbors, and canals of Honolulu on Oahu.

Sediment Toxicity

Hawaii's coastal waters are rated good for sediment toxicity, with 97% of the coastal area rated good and 3% of the area rated poor for this component indicator. Toxic sediments were found at only two sites (Wahiawa Bay, Kauai, and Kaneohe Bay, Oahu), and sediment samples from these sites also exhibited elevated levels of arsenic and DDT, respectively. Since no other sediment contaminant concentrations were elevated at these sites, it is unclear whether the sediment toxicity was directly caused by the contamination.

Small sea anemone on volcanic rock (courtesy of NOAA, National Undersea Research Program).

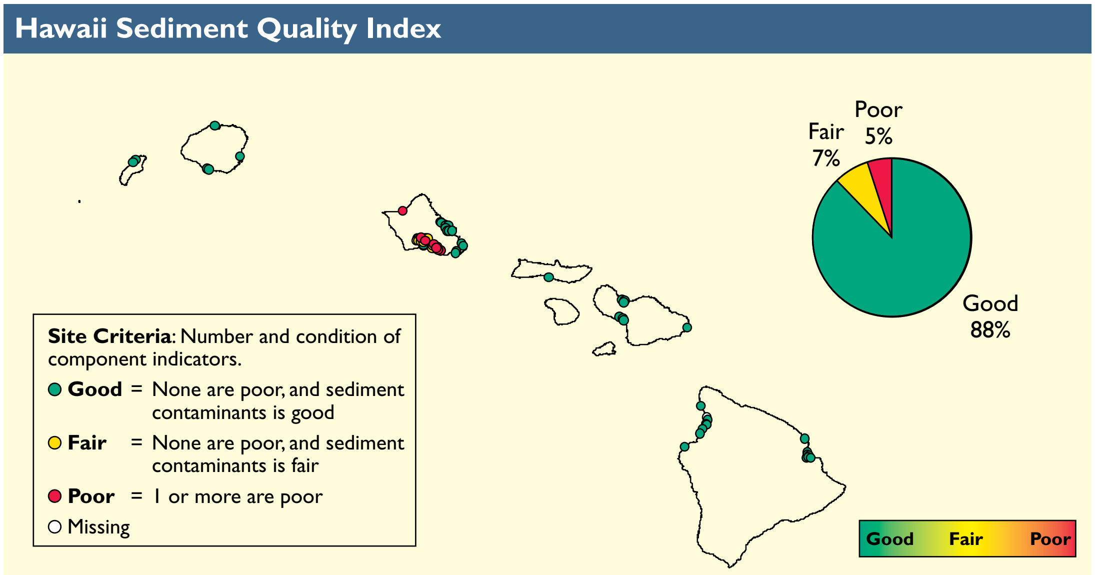


Figure 8-13. Sediment quality index data for Hawaii's coastal waters (U.S. EPA/NCA).

Sediment Contaminants

Hawaii's coastal waters are rated good for sediment contaminant concentrations, with 7% of the coastal area rated fair and 2% of the area rated poor for this component indicator. Six of the 7 sites rated poor were located in the urbanized estuaries of Oahu, and the remaining site was located in Paukaulia Stream on the north shore of Oahu. Primarily, these sites exhibited elevated levels of copper and mercury; however, high concentrations of chromium and PAHs were found in sediments collected from Paukaulia Stream and Honolulu Harbor, respectively. All of the sites rated fair were located in the urbanized estuaries of Oahu and were primarily rated fair due to elevated concentrations of metals (e.g., chromium, copper, lead, mercury, silver, zinc) and some individual PAHs.

It should be noted that nickel was excluded from this evaluation of sediment contamination in Hawaii's coastal waters because the ERM value for this metal has a low reliability for areas of the West Coast, where high natural crustal concentrations of nickel exist (Long et al., 1995). A study of metal concentrations in cores collected along the West Coast determined the range of historic background concentrations of nickel to be 35–70 ppm (Lauenstein et al., 2000), which brackets the value of the ERM (51.6 ppm). Some researchers have also suggested that West Coast crustal concentrations for mercury may be naturally elevated, although no conclusive evidence is available to support this suggestion; therefore, mercury data were not excluded from this assessment. In addition, it should be noted that only one exceedance was counted if a site exceeded the ERL for low molecular weight PAHs, high molecular weight PAHs, and/or total PAHs to ensure that the analysis was not biased by PAHs.

Sediment TOC

The coastal waters of Hawaii are rated good for sediment TOC. A total of 8% of the coastal area was rated fair, and none of the area was rated poor. The majority of sites that were rated fair for sediment TOC were located within Pearl Harbor, which is both extensively modified and has a restricted connection to the ocean. Sites in Reeds Bay and Hilo Bay on the island of Hawaii were also rated fair.

Benthic Index

Benthic condition in Hawaii's coastal waters as measured by a benthic index could not be evaluated. As was the case for Alaska, a benthic condition index for Hawaii is not currently available. In lieu of a benthic index for Hawaii, the deviation from an estimate of expected species richness was used as an approximate indicator of the condition of the benthic community. This approach requires that species richness be predicted from salinity, and, in the case of the Hawaii survey data, the regression was not significant.

Coastal Habitat Index

Estimates of coastal habitat loss are not available for Hawaii; therefore, a coastal habitat index could not be calculated. It is clear that there have been major alterations and losses of coastal wetlands in Hawaii. Modification of coastal wetlands prior to western contact was probably generally limited to the conversion of these marshes into taro cultivation ponds. Later, agricultural activities (e.g., cattle ranching, sugarcane/pineapple production) in the islands modified or eliminated many coastal wetlands. Commercial and military navigation projects also resulted in losses of wetlands on Kauai, Maui, Oahu, and Hawaii; however, perhaps the most extensive loss of coastal wetlands occurred as the result of housing and resort construction following World War II, heavily impacting wetlands on Oahu (Meier et al., 1993).

Fish Tissue Contaminants Index

The NCA survey of Hawaii did not produce estimates of contaminant levels in fish. Instead, a preliminary feasibility study was conducted to determine whether sea cucumbers could be utilized to assess tissue body burdens. Samples of two species of sea cucumbers were analyzed for tissue contaminant levels in the pilot method-development effort. Some heavy metals (e.g., mercury, cadmium, silver) were undetected in sea cucumber tissue samples. PCBs and DDT were detected at low levels in some tissue samples, whereas PAHs and other pesticides were not detected. These results have a high degree of uncertainty because the total sample size was small and analytical issues were present with the tissue matrix. As a result, a fish tissue contaminants index could not be calculated for Hawaii.

Large Marine Ecosystem Fisheries—Insular Pacific-Hawaiian LME

The Insular Pacific-Hawaiian LME surrounds the Main Hawaiian Islands (MHI) of Hawaii, Maui, Lanai, Molokai, Oahu, Kauai, and Niihau, as well as the Northwestern Hawaiian Islands (NWHI) (Figure 8-14). This tropical LME is influenced by equatorial currents and predominantly northeasterly trade winds. The Insular Pacific-Hawaiian LME is classified as a low-productivity ecosystem based on estimates of primary productivity (phytoplankton). The waters of this LME have high levels of marine diversity and support a variety of fisheries; however, maximum sustainable yields are relatively low due to limited ocean currents. The NMFS manages this LME as part of its Western Pacific Region, which includes the fisheries of American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, and other U.S. Pacific island possessions (NOAA, 2007g).

In 2006, the NWHI were designated as a U.S. Marine National Monument. The islands extend from 160 miles northwest of Kauai into the Pacific Ocean approximately 1,200 miles, cover nearly 140,000 mi^2 of ocean, and include 70% of the tropical, shallow-water coral reefs in U.S. waters. Commercial and recreational harvest of precious coral, crustaceans, and coral reef species are prohibited in monument waters, and commercial fishing is being phased out over a 5-year period. Commercial activities within the state waters of the NWHI were banned in 2005. Additional information about the Marine National Monument is available at: http://www.hawaiireef.noaa.gov.

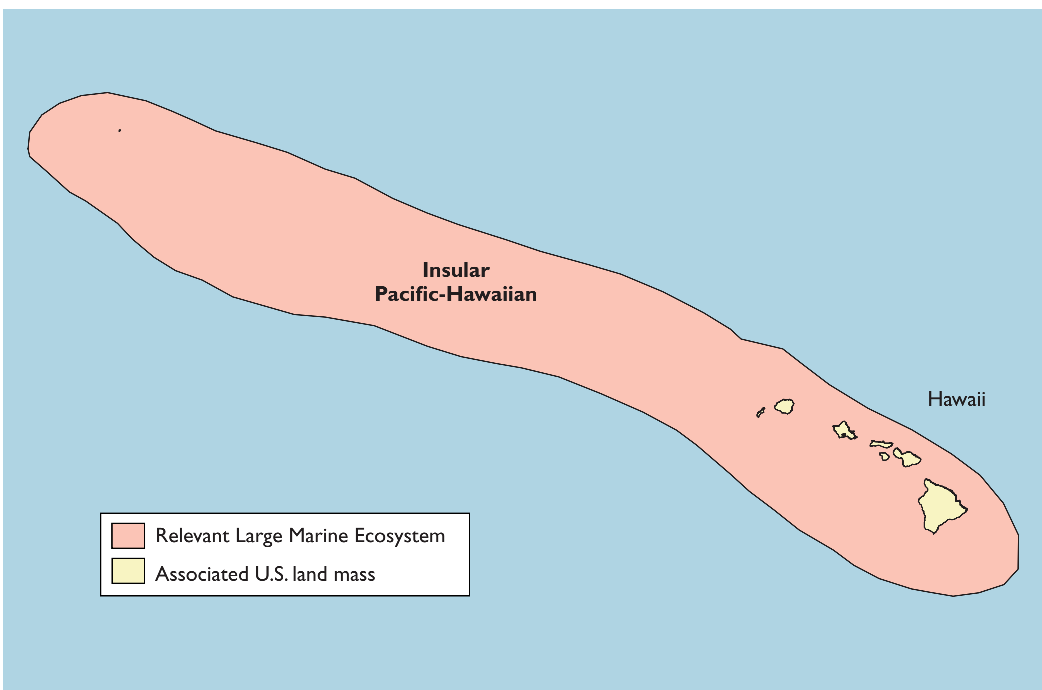


Figure 8-14. Insular Pacific-Hawaiian LME (NOAA, 2007g).

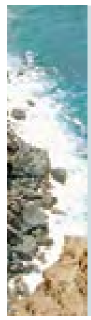
Invertebrate Fisheries

The dominant invertebrate species fished in the state, territorial, commonwealth, and remote island waters of the NMFS Western Pacific Region include lobsters, shrimp, squid, octopus, and precious corals. Most of these fisheries operate on a small scale and are regulated solely by local island fisheries agencies. The NWHI lobster fishery and the Hawaii precious coral fishery are the only invertebrate fisheries managed by NMFS in this area. Although the NWHI lobster trap fishery is the major commercial marine invertebrate fishery in this region, small-scale, primarily recreational fisheries for different species of lobster exist in the MHI, American Samoa, Guam, and the Northern Mariana Islands. A resource of deep-water precious coral (gold, bamboo, and pink corals) and shallow-water coral (black) exists in Hawaii and possibly other western Pacific areas. A short-lived, domestic precious coral fishery operated in Hawaii from 1974 to 1979, but there was no significant precious coral harvest for 20 years until 1999 through 2001. A deep-water shrimp resource is found throughout the Western Pacific Region, but currently is relatively unexploited (NMFS, In press).

Northwestern Hawaiian Islands Lobster

A commercial lobster trap fishery operated in the NWHI from the mid-1970s through 1999. Although this multi-species fishery primarily targeted the Hawaiian spiny lobster and slipper lobster, three other species (green spiny lobster, ridgeback slipper lobster, and Chinese slipper lobster) were caught in small numbers. Historically, traps set at deeper depths caught slipper lobster, while the shallower sets caught spiny lobster. In later years, slipper lobsters (particularly at Maro Reef) have been caught at shallow depths; this shift was presumably caused in part by the fishing pressure on spiny lobsters and the availability of suitable habitat formerly occupied by spiny lobster (NMFS, In press).

The estimated populations of spiny and slipper lobsters declined dramatically from the mid-1980s through the mid-1990s. Much of this decline has been attributed to a shift in oceanographic conditions that affected recruitment in the mid-1980s. Although oceanographic conditions have returned to a more typical long-term state and the fishery has been closed since 2000, recent NMFS research surveys have not indicated any increase in spiny lobster populations at Necker Island or Maro Reef. Variability in oceanographic conditions may have contributed to the decline of NWHI spiny lobster; however, improvements in our understanding of the spatial structure of the NWHI spiny lobster population, the dynamics of larval transport, and commercial fishery data suggest that spiny lobster populations in the NWHI constitute a metapopulation and that a suite of factors (both anthropogenic and biotic) contributed to the observed decline (NMFS, In press).



A metapopulation is a group of populations inhabiting discrete patches of suitable habitat that are connected by the dispersal of individuals between patches; the degree of isolation for local populations may vary depending on the distance between habitat patches.

Precious Coral

The waters of the MHI host commercial fisheries for deep-water and shallow-water corals. For the first time since the mid-1970s, deep-water precious corals (pink, gold, and bamboo corals) were harvested commercially in Hawaii from 1999 to 2001. A single company collected corals at the established coral-harvesting bed of Makapu'u, Oahu, and in an exploratory coral harvesting bed off Keahole, Hawaii. The allowable harvest quotas were not filled in either location. Although the fishery remains open, the company has suspended harvesting activities due to the high cost of operating submarines and the low bid price for coral. The only shallow-water coral species that are currently harvested are black corals. Black corals are collected by three independent divers working at depths less than 260 ft; all within the Au'au Channel, Maui (NMFS, In press).

In 2000 and 2001, scientists surveyed all known deep-water and shallow-water precious coral beds in the Hawaiian Archipelago using submersibles that belong to the Hawaii Undersea

Research Laboratory. These surveys provided the first real insight into the relative abundance of precious corals across the archipelago. Post-harvest inspections of the deep-water coral beds at Makapu'u and Keahole found numerous live colonies and little evidence of damage associated with commercial coral-harvesting activities. The 2001 survey of the Makapu'u bed will be compared with pre-harvest survey data collected at Makapu'u in 1997 to evaluate possible harvesting impacts. Both divers and submersibles were used to survey the black coral bed of the Au'au Channel in 2000 and 2001. At depths shallower than 260 feet, divers surveyed the size structure of black coral trees and their associated fish assemblages. The submersible surveys conducted at depths below 260 feet observed an invasive species of soft coral (*Carijoa riisei*) overgrowing black coral trees. A follow-up survey of coral size and structure was conducted in 2004 and will be used to revisit the harvesting regulations presently in place (NMFS, In press).

Deep-sea coral on seamount in Northwest Hawaiian Islands (courtesy of NOAA Office of Ocean Exploration).

Monitoring the activities related to the precious coral fishery in Hawaii is important because these activities and their effects could possibly interfere with the feeding habits of endangered Hawaiian monk seal populations. Studies of monk seal foraging patterns using seal-mounted satellite tags documented a small number of seals visiting sites with deep-water precious coral beds (Parrish et al., 2002). Another study recorded seals visiting black coral beds on successive nights to feed on eels hiding amongst the corals. These and other studies of seal diving and foraging behavior have spurred concern that coral harvesting might impact the seals' use of the deep-water fish community. In 2003, a seal was observed by a submersible at a depth of about 1,750 feet near precious coral, further strengthening the link between seals and precious coral beds (NMFS, In press).

Demersal Fish and Armorhead Fisheries

The Western Pacific Region hosts fisheries for demersal fish and pelagic armorhead. The demersal fish fishery geographically encompasses the Insular Pacific-Hawaiian LME, Guam, the Commonwealth of the Northern Mariana Islands, and American Samoa. In contrast, pelagic armorhead are harvested in this region from the summits and upper slopes of a series of submerged seamounts along the southern Emperor-northern Hawaiian Ridge. This chain of seamounts is located just west of the International Date Line and extends into the northernmost portion of the NWHI.

Demersal Fish

The Guam, Commonwealth of the Northern Mariana Islands, American Samoa, and MHI demersal fish fisheries employ relatively small vessels on one-day trips close to port; either part-time or sport fishermen take much of the catch. In contrast, demersal fish in the NWHI are fished by full-time fishermen on relatively large vessels that range far from port on trips of up to 10 days. Fishermen use the hand-lining technique in which a single weighted line with several baited hooks is raised and lowered with a powered reel. The demersal fish fisheries are managed jointly by the Western Pacific Fishery Management Council and territorial, commonwealth, or state authorities (NMFS, In press).

In Hawaii, the demersal fish species fished include several snappers (ehu, onaga, opakapaka, and uku), jacks (ulua and butaguchi), and a grouper (hapu'upu'u). In the more tropical waters of Guam, the Commonwealth of the Northern Mariana Islands, and American Samoa, the fisheries include a more diverse assortment of species within the same families as in Hawaii, as well as several species of emperors. These species are found on rock and coral bottoms at depths of 170 to 1,350 feet. Catch weight, size, and fishing effort data are collected for each species in the five areas (i.e., MHI, NWHI, Guam, Commonwealth of the Northern Mariana Islands, American Samoa); however, the sampling programs vary in scope between these areas. About 90% of the total landings are taken in Hawaii, with the majority of the landings taken in the MHI. Although somewhat limited, stock assessment indicate that the spawning stocks of several important MHI species (ehu, hapu'upu'u, onaga, opakapaka, and uku) are at only 5% to 30% of unfished levels. Onaga and ehu presently appear to be the most stressed among MHI demersal fish species (NMFS, In press).

Pelagic Armorhead

The seamount demersal fish fishery has targeted just one species—the pelagic armorhead. The commercial seamount fishery for pelagic armorhead was started by bottom-trawl vessels of the former Soviet Union in 1968. During 1969, Japanese trawlers entered this fishery, and by 1972, CPUE (based on Japanese data) peaked at 54 t per hour. The United States has never been a participant in this fishery. By the end of 1975, the two foreign fleets had harvested a combined cumulative total of 1,000,000 t of pelagic armorhead. Facing a steady decline in CPUE beginning in 1972, the former Soviet fleet left the fishery after 1975. The combined catch index for all seamounts has remained depressed since the late 1970s. In 1977, the southermost seamounts (Hancock Seamounts) were included in the EEZ, and subsequently, a small portion of the fishery was managed in a limited way. A preliminary FMP was developed that year and provided for limited foreign harvesting at the Hancock Seamounts under a permit system between 1978 and 1984 (NMFS, In press). However, catches remained low, and all fishing in this area ceased after 1984. Under the FMP for this region's demersal fish fisheries (WPRFMC, 1986), a 6-year fishing moratorium was imposed on the Hancock Seamounts in 1986. The moratorium was extended for three additional 6-year periods, the latest starting in 2004 and ending in 2010 (NMFS, In press).

Since 1976, Japanese trawlers have conducted this fishery almost exclusively around the seamounts in international waters beyond the Hancock Seamounts. The fishing grounds of the Hancock Seamounts represent less than 5% of the total fishing grounds for the pelagic armorhead. The maximum sustainable yield is 2,123 t, but recovery to the fishery's former levels has not yet occurred. Standardized stock assessments were conducted between 1985 and 1993. Research cruises focused on Southeast Hancock Seamount, and the armorhead stock was sampled with bottom long lines and calibrated against Japanese trawling effort. Catch rates varied, but have not shown the increases expected after the fishing moratorium was implemented. Furthermore, the increase in the 1992 seamount-wide CPUE caused by high recruitment was apparently short lived because CPUE declined appreciably in 1993 and thereafter. Closure of only the small EEZ portion of the pelagic armorhead's demersal habitat may not be sufficient to allow population recovery because these seamounts remain the only part of the fishery currently under management. The primary issue for the armorhead seamount fishery is how to implement some form of management on an international basis to provide conditions conducive to stock recovery (NMFS, In press).

Kona coast (courtesy of Calbear22).

Assessment and Advisory Data

Fish Consumption Advisories

Since 1998, the State of Hawaii has advised the general population not to consume fish or shellfish caught in the Pearl Harbor area on the island of Oahu due to PCB contamination (Figure 8-15). In addition to the existing estuarine advisory, a statewide advisory took effect in 2003. The new statewide advisory targets sensitive populations (e.g., pregnant women, nursing mothers, children) and provides data on mercury contamination for several species of marine fish (U.S. EPA, 2004b).

Beach Advisories and Closures

Hawaii did not report monitoring, advisory, or closing information for any beaches in 2003 (U.S. EPA, 2006c).

Freshwater pools leading to the ocean in Haleakala National Park on the southeastern coast of Maui (courtesy of NPS).

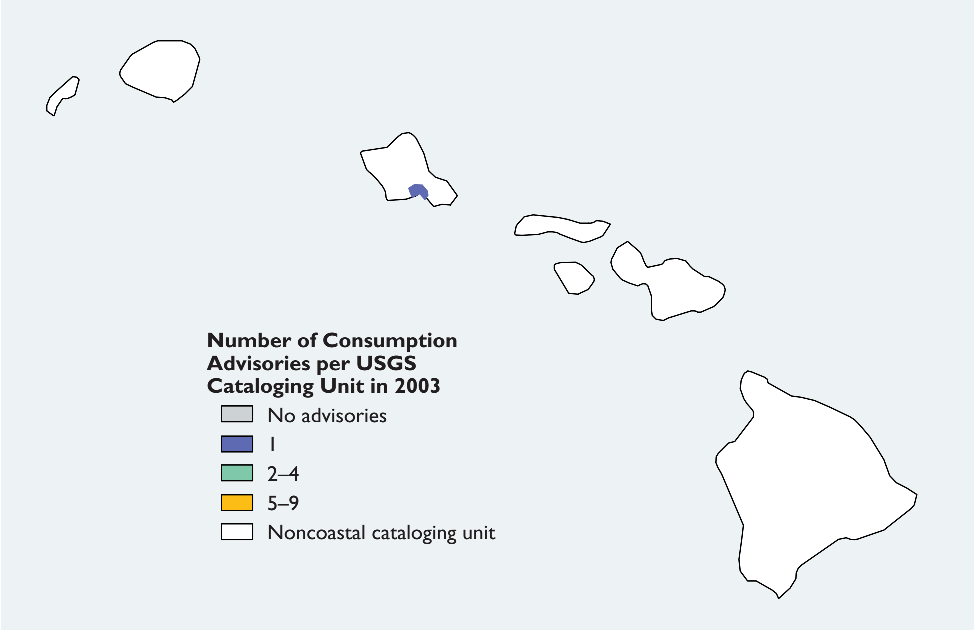


Figure 8-15. Fish consumption advisory for Hawaii, location approximate. Hawaii also has a statewide advisory for marine fish consumption by sensitive populations, although this is not mapped (U.S. EPA, 2004b).

Puerto Rico

Coastal Monitoring Data—Status of Coastal Condition

The overall condition for Puerto Rico's coastal waters presented in the NCCR II (U.S. EPA, 2004a) was poor based on three of the indices used by NCA (Figure 8-16). The water quality index is rated fair, and the sediment quality and benthic indices are rated poor. NCA was unable to evaluate the coastal habitat or fish tissue contaminants indices for Puerto Rico. Figure 8-17 provides a summary of the percentage of coastal area in good, fair, poor, or missing categories for each index and component indicator. This assessment was based on the results of sampling conducted at 50 sites in 2000. Please refer to Chapter 1 for information about how these assessments were made, the criteria used to develop the rating for each index and component indicator, and limitations of the available data.

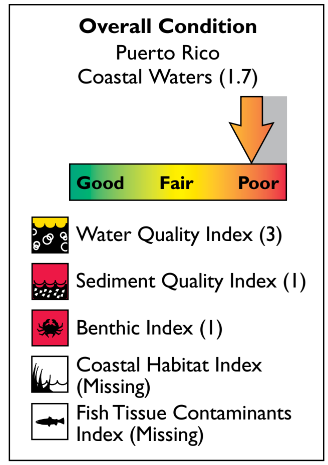


Figure 8-16. The overall condition of Puerto Rico's coastal area is rated poor (U.S. EPA/NCA).

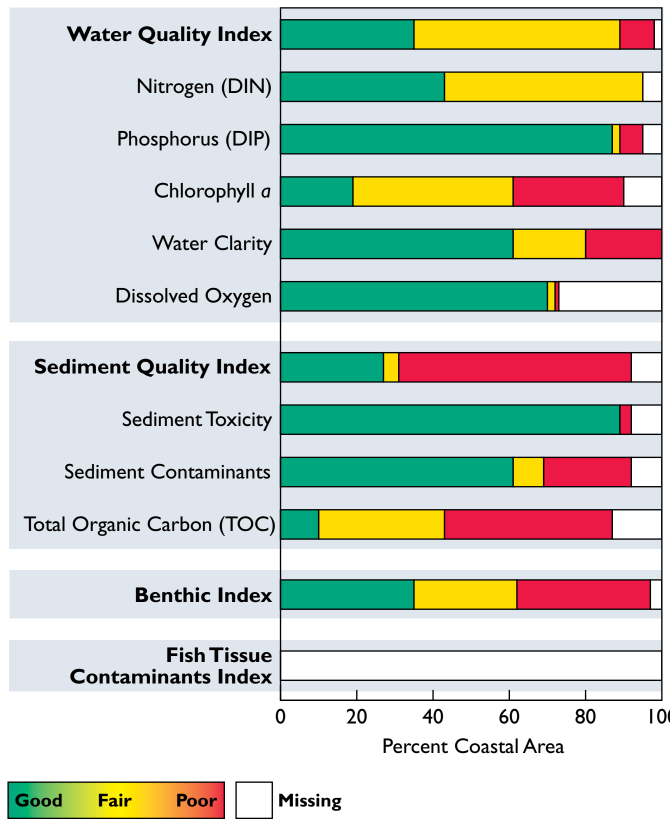


Figure 8-17. Percentage of area receiving each ranking for all indices and component indicators – Puerto Rico (U.S. EPA/NCA).

In Puerto Rico, manatees are most abundant along the south and east coasts of the island (courtesy of USGS).

Although another NCA sampling event for Puerto Rico occurred in 2004, these results are not yet available for publication and will be presented in the NCCR IV. This section of the NCCR III summarizes the results that were presented in NCCR II. The NCCR II assessment indicated that, for the indices and component indicators measured, the primary problems in Puerto Rico's coastal waters are degraded sediment quality, degraded benthos, and some areas of poor water quality. Sampling stations with consistently low scores for the water quality, sediment quality, and benthic indices were located in San Juan Harbor, the Caño Boquerón, Laguna del Condado, and Laguna San José.

Water Quality Index

As described in the NCCR II, the water quality index for Puerto Rico's coastal waters is rated fair. This water quality index was developed using five water quality indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Although only 9% of the coastal area was rated poor, 63% of the area was rated poor and fair, combined (Figure 8-18). Nutrient levels were rated fair and good for DIN and DIP, respectively. Low scores for chlorophyll *a* (poor) and water clarity (fair) contributed to the overall rating. Dissolved oxygen concentrations in Puerto Rico coastal waters were rated good. Estimates showed that only 1% of bottom waters have hypoxic conditions (< 2 mg/L) on a continuing basis in late summer; however, dissolved oxygen data were missing for 27% of the coastal area.

Limestone cliffs near Los Morillos Lighthouse, Cabo Rojo, PR (courtesy of Smylere Snape).

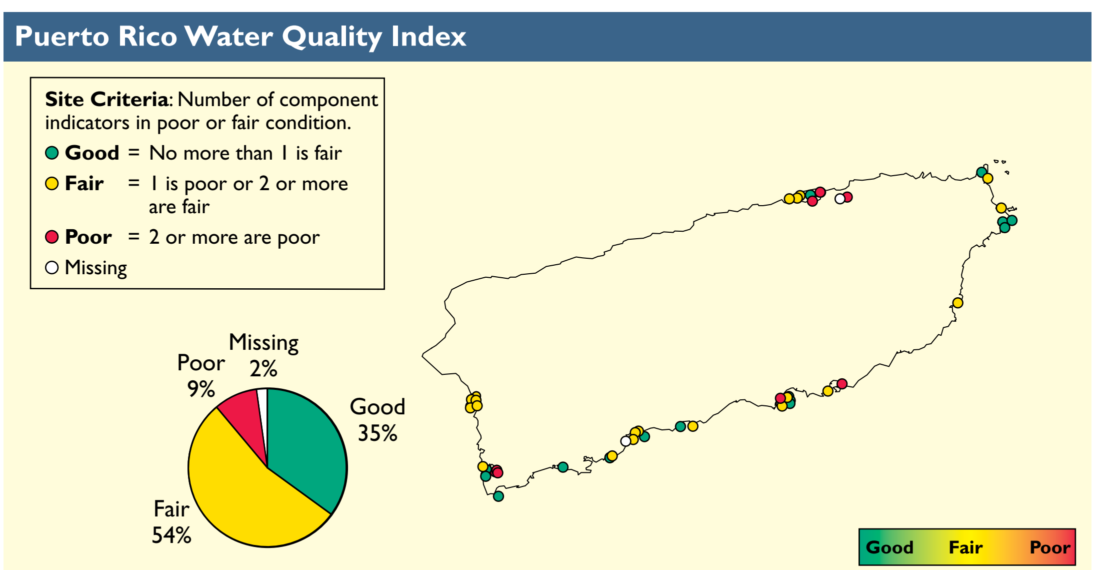


Figure 8-18. Water quality index data for the coastal waters of Puerto Rico (U.S. EPA/NCA).

Highlight

The Condition of Coral Reefs in Puerto Rico and the U.S. Virgin Islands

The current condition of coral reef ecosystems in Puerto Rico and the U.S. Virgin Islands, which constitute the U.S. Caribbean, was summarized recently in the report *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005* (Waddell, 2005). This report contains quantitative results of assessment and monitoring activities conducted in shallow-water coral reef ecosystems by federal, state, territory, commonwealth, non-government, private, and academic partners. Additionally, it is based primarily on recent, quantitative monitoring data collected *in situ* in each of 14 jurisdictions, including the U.S. Virgin Islands, Puerto Rico, Florida, Navassa Island, Flower Garden Banks, and other banks in the Gulf of Mexico, MHI, NWHI, U.S. Pacific Remote Island Areas, American Samoa, Commonwealth of the Northern Mariana Islands, Guam, and the Freely Associated States of the Republic of the Marshall Islands, the Federated States of Micronesia, and the Republic of Palau.

Coral reef ecosystems in the U.S. Caribbean comprise a mosaic of habitats that host a large diversity of marine organisms, including coral and other hard-bottom areas, seagrass beds, and mangroves. These biologically rich ecosystems provide important services to coastal areas (e.g., shoreline protection) and support valuable socio-economic activities (e.g., fishing, tourism); however, coral reefs are also affected directly and indirectly by these activities. Coral reefs generally form three types of reef structures: fringing reefs, patch reefs, or spur and groove reefs. These structures are distributed around the islands (Adey, 1975; Hubbard et al., 1993; Garcia-Sais et al., 2003). Recent estimates of the spatial extent of coral reef ecosystems from Landsat satellite imagery indicate that coral reef ecosystems in Puerto Rico and the U.S. Virgin Islands potentially cover about 1,022 mi^2 within the 60-ft depth contour or 2,945 mi^2 within the 600-ft depth contour (Rohmann et al., 2005).

Coral reef ecosystems in the U.S. Caribbean face several threats, including climate change, disease, tropical storms, coastal development and runoff, coastal pollution, tourism and recreation, fishing, and ships, boats, and groundings. Point and non-point source discharges into the marine environment remain a major concern and may be contributing to an increase in the abundance and incidence of coral diseases, such as black band disease. Where they exist, rivers represent the main sources of pollutants and sediments to coastal waters (CH2M Hill, Inc., 1979; Anderson and MacDonald, 1998; IRF, 1999).

In Puerto Rico, the highest cover of live corals generally occurs on reefs located on the leeward side of the islands (e.g., Desecheo, Mona); at offshore islands (e.g., Vieques, Culebra, Cayo Diablo); and along the south and west coast of the main island (e.g., La Boya Vieja, Tourmaline). Boulder star coral (*Montastrea annularis*) is the dominant coral species on reefs with relatively high coral cover, whereas the great star coral (*Montastrea cavernosa*), massive starlet coral (*Siderastrea spp.*), and finger coral (*Porites astreoides*) constitute the main coral assemblage of degraded reefs. Coral reefs with high live coral cover generally exhibit relatively a high abundance and diverse assemblage of zooplanktivorous fishes (such as *Chromis spp.*, *Clepticus spp.*, and *Stegastes partitus* that feed on zooplankton), whereas coral reefs with low live coral cover are dominated numerically by a single species, the dusky damselfish (*Stegastes dorsopunicans*) (Garcia-Sais et al., 2005).

In the U.S. Virgin Islands, current assessments indicate that marine water quality is good, but declining because of increases in point and non-point sources of pollution. Generally, coral cover on reefs is low relative to the abundance of macro- and filamentous algae, which indicate a possible phase-shift from coral-dominated reefs to algal-dominated reefs. Additionally, the dense stands of elkhorn coral (*Acropora palmata*) that were once the dominant shallow-water species of coral in some areas four decades ago have not recovered (Jeffrey et al., 2005).

Large flower corals in coral reefs communities in the Jobos Bay NERR (NOAA).

Several management actions have been taken to conserve coral reef ecosystems in the U.S. Caribbean. Marine-protected areas have been established or expanded throughout Puerto Rico and the U.S. Virgin Islands to provide varying levels of protection for resources and to serve as fishery management tools. Puerto Rico's Department of Natural and Environmental Resources recently revised fisheries laws to halt major declines in recreational and commercial catches, which have fallen as much as 70% between 1979 and 1990 (Garcia-Sais et al., 2005). In the U.S. Virgin Islands, 3,250 mooring buoys have been installed to reduce ship groundings and protect benthic habitats from anchor damage caused by commercial and recreational boat usage. Recent monitoring data from marine protected areas in both Puerto Rico and the U.S. Virgin Islands suggest that commercially important reef fishes such as red hind grouper (*Epinephelus guttatus*) are increasing in size and abundance within reserve boundaries (Jeffrey et al., 2005; Nemeth, 2005).

Although these management actions have had some success in protecting coral reef ecosystems, they could be more effective with greater enforcement. Current coral reef ecosystem conditions would improve further with

- Reductions in the number and intensity of the major threats affecting coral reefs
- Greater enforcement of existing marine protected areas and regulations that govern resource use and extraction
- Increased environmental education and awareness among island residents and visitors.

Additionally, coral reef ecosystems in the U.S. Caribbean would benefit substantially from stronger coordination and collaboration among the federal, territorial, and non-governmental agencies and organizations that have an interest in marine conservation in these islands.

Sediment Quality Index

Overall, sediment quality in Puerto Rico's coastal waters is rated poor. A sediment quality index was developed for Puerto Rico coastal waters using three sediment quality component indicators: sediment toxicity, sediment contaminants, and sediment TOC. More than 60% of Puerto Rico's coastal area was rated poor for one or more of the component indicators (Figure 8-19). Puerto Rico's sediment toxicity was rated good because only 3% of the coastal area contained sediments that were toxic to the test organism. The sediment contaminants component indicator was rated poor in 23% of the coastal area. Puerto Rico sediments were also rated poor with respect to sediment TOC. In this area, elevated sediment TOC values are often associated with contributions to a waterbody's organic loads from untreated wastewater, agricultural runoff, and industrial discharges; however, occasionally, these levels are associated with natural processes in mangrove estuaries. Although it is difficult to discern whether the high levels of TOC in Puerto Rico are due to anthropogenic sources or natural mangrove habitat, many of the areas rated poor for TOC are also relatively devoid of mangrove systems and are known to have high levels of poorly treated sewage discharge.

Benthic Index

The benthic index for Puerto Rico's coastal waters is rated poor, with 35% of the coastal area rated poor (Figure 8-20). Currently, no benthic community index has been developed for Puerto Rico. As a surrogate for benthic condition, the benthic samples were evaluated using standard ecological community indicators: biological diversity, species richness, and abundance. Biological diversity and species richness are measurements that contribute to all of the benthic indices developed by the NCA in the Northeast Coast, Southeast Coast, and Gulf Coast regions. Biological diversity is directly affected by natural gradients in salinity and silt-clay content. Analyses using Puerto Rico data showed no significant relationships between benthic diversity and either salinity or silt-clay content; therefore, benthic diversity was used to directly evaluate benthic condition.

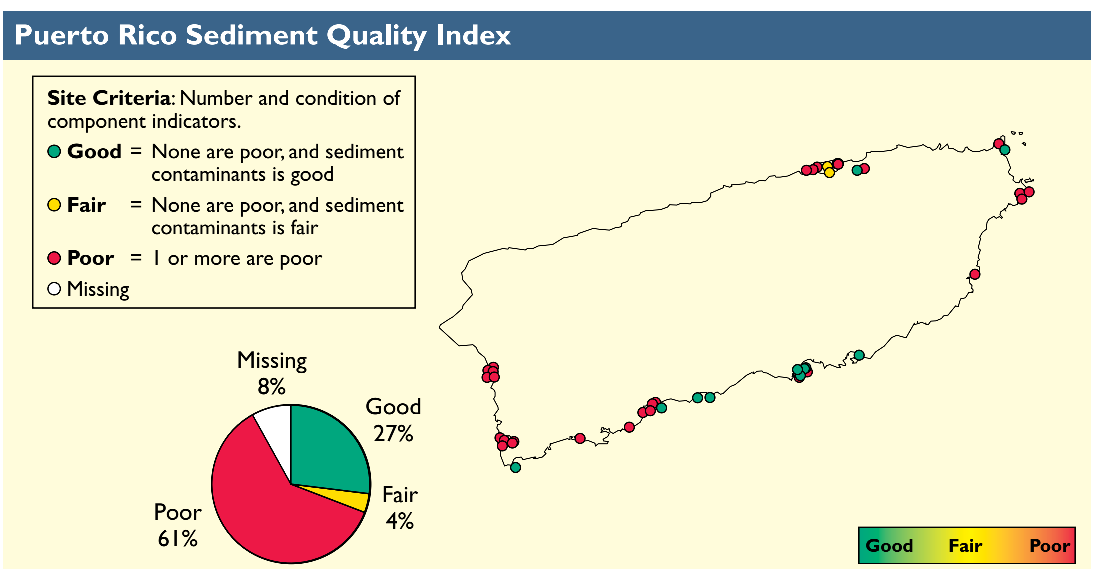


Figure 8-19. Sediment quality index data for the coastal waters of Puerto Rico (U.S. EPA/NCA).

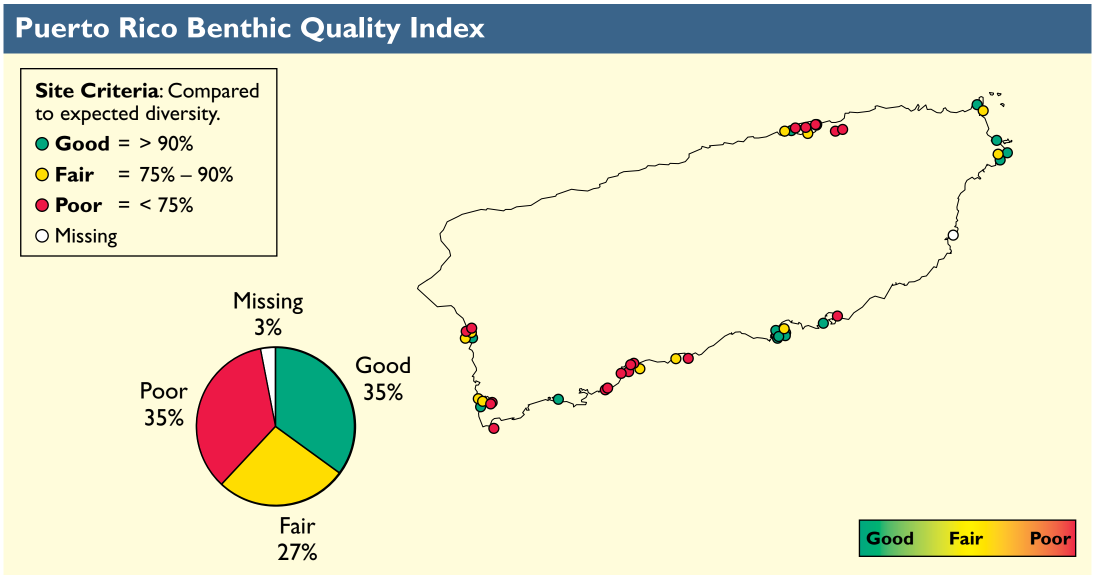


Figure 8-20. Benthic index data for the coastal waters of Puerto Rico (U.S. EPA/NCA).

Coastal Habitat Index

Estimates of coastal habitat loss are not available for Puerto Rico; therefore, the coastal habitat index could not be calculated.

Fish Tissue Contaminants Index

Estimates of fish tissue contaminants are not available for Puerto Rico; therefore, the fish tissue contaminants index could not be calculated. In conjunction with the San Juan Bay Estuary Partnership, fish tissue sampling was conducted in the San Jose Lagoon, and the results are available in the NEP CCR (U.S. EPA, 2006b).

Castillo de San Felipe del Morro, also known as El Morro, in San Juan, PR (courtesy of Tony Santana, USACE).

Large Marine Ecosystem Fisheries—Caribbean Sea LME

Puerto Rico is located within the Caribbean Sea LME (Figure 8-21). This semi-enclosed LME is bounded by the Southeast U.S. Continental Shelf and Gulf of Mexico LMEs to the north, Central America to the west, South America to the south, and the Atlantic Ocean to the east. The Caribbean Sea LME is considered a low-productivity ecosystem with localized areas of higher productivity along the coast of South America. This LME is bordered by 38 countries and dependencies and lacks a coordinated effort to monitor and manage the ecosystem (NOAA, 2007g). There is no information available for the fisheries of this LME.

Assessment and Advisory Data

Fish Consumption Advisories

Puerto Rico did not report fish consumption advisory information to EPA in 2003 (U.S. EPA, 2004b).

Beach Advisories and Closures

Puerto Rico did not report monitoring, advisory, or closing information for any beaches in 2003 (U.S. EPA, 2006c).

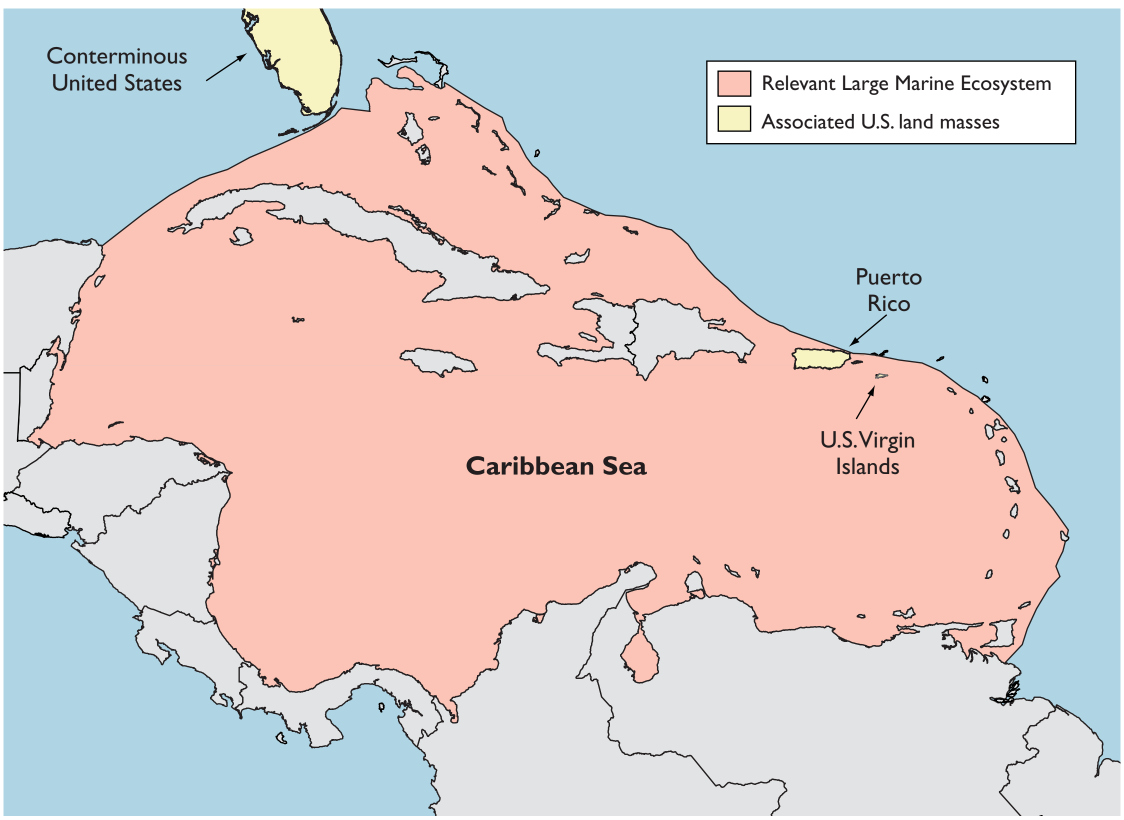


Figure 8-21. Caribbean Sea LME (NOAA, 2007g).

American Samoa, Guam, Northern Mariana Islands, U.S. Virgin Islands

Coastal Monitoring Data—Status of Coastal Condition

American Samoa, Guam, the Northern Mariana Islands, and the U.S. Virgin Islands were not assessed by NCA in 2001 or 2002. American Samoa, Guam, and the Northern Mariana Islands are located in the Pacific Ocean (Figure 8-22), and the U.S. Virgin Islands are found in the Caribbean Sea (Figure 8-21).

Large Marine Ecosystem Fisheries

Guam, the Northern Mariana Islands, and American Samoa are not located within an LME. The NMFS Western Pacific Region manages the fisheries in these waters in conjunction with those of the Insular Pacific-Hawaiian LME. These fisheries were discussed in the Hawaii section of this chapter. The U.S. Virgin Islands are located within the Caribbean Sea LME, which is discussed in the Puerto Rico section of this chapter.

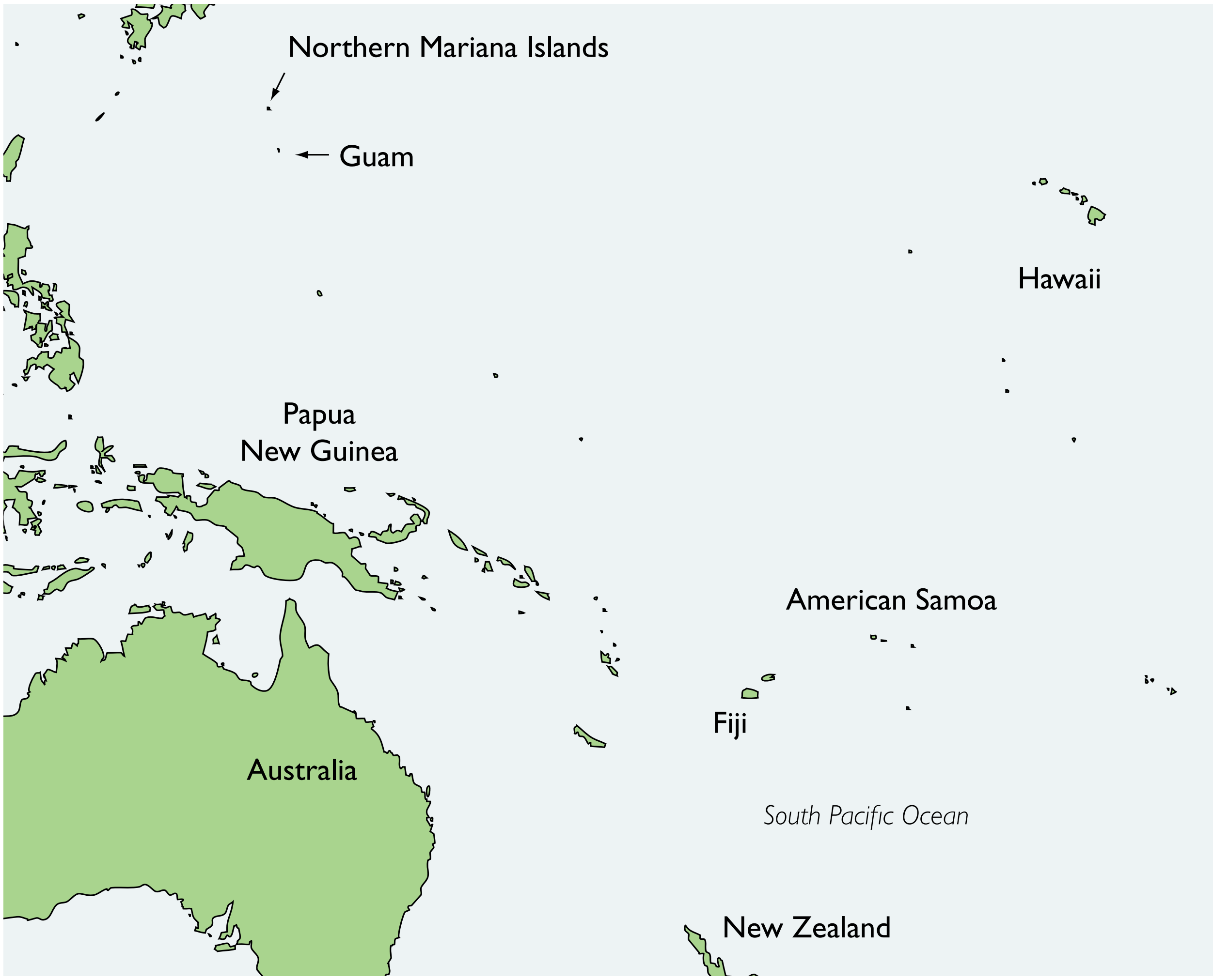


Figure 8-22. Locations of the U.S. Pacific island territories (U.S. EPA/NCA).

Highlight

The NCA Survey of Guam, 2004

The island of Guam is a 212-mi^2, unincorporated territory of the United States, with a population of approximately 166,000 residents. The entire island of Guam is classified as a coastal zone. Practically all residences are served by public/military community water supply systems, with a large number of single-family dwellings using individual septic tank/leaching field systems. Approximately 1 million tourists visit Guam annually, largely drawn by the island's tropical climate and clean, recreational, fresh and marine waters. The Guam Environmental Protection Agency currently monitors some indicators of the physical and chemical condition of marine receiving waters; however, the lack of quantitative baseline information for water, sediment, and tissue pollutant concentrations limits the ability to provide a comprehensive assessment of receiving waterbodies. The establishment of long-term comprehensive monitoring programs is needed as a first step toward developing any program of pollution abatement and habitat restoration. As a first step in this process, the Guam Environmental Protection Agency has participated in the NCA survey (Guam Environmental Protection Agency, 2006).

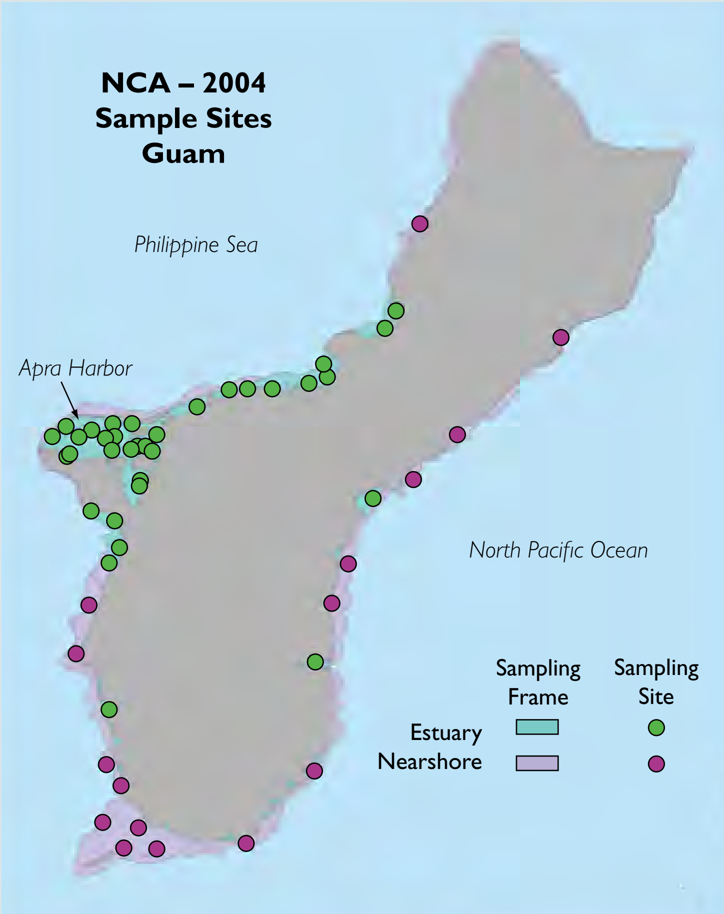
The Guam component of the NCA survey is based on a combination of the procedures and methods of the NCA coupled with specialized methods for sampling hard-bottom habitats such as coral reefs (Guam Environmental Protection Agency, 2006). These specialized methods were first developed and used by the 2002 NCA assessment for Hawaii (Nelson et al., 2007). Thus, the Guam assessment is consistent with the broader NCA, while taking into account modifications that have been developed for tropical coral reef island environments.

The Guam NCA survey used some of the same indices and indicators as the NCA surveys of other regions, but some indices/indicators were added or modified. The Guam assessment included such standard NCA indices as the fish tissue contaminants index and the benthic index, as well as component indicators such as water-column nutrient levels, bottom-water dissolved oxygen concentrations, water clarity, and sediment contaminant concentrations. Coral disease identification is under consideration as an indicator for use in future monitoring efforts. The major modifications to the NCA index/indicator list and protocols include the following:

- Replacement of fish trawls, which are very destructive to coral reef communities, with visual census protocols in conjunction with reef and pelagic fish standing stock estimates for fish community assessments
- Use of sea cucumber or crab samples rather than fish samples for the fish tissue contaminants index
- Addition of storm wave-impact estimates
- Addition of water-column analyses for microbial contamination
- Addition of hard-bottom benthic habitat monitoring using transect and quadrat measurements of the percent cover of macroinvertebrate and algal composition on rock outcrops and coral substrates (Guam Environmental Protection Agency, 2006).

The coastal resource definition for the NCA in Guam encompasses all waters with salinity greater than 0.5 psu and a depth between mean low water and the 60-ft depth contour. Within this depth contour, two sampling strata were created. The estuary stratum consisted of estuaries and more protected embayments, whereas the nearshore stratum consisted of the more open coastlines of the island. There was one exception to the depth criterion. NCA sampling was conducted in Apra

Harbor, which was designated as a special study area where water depth often exceeds 60 feet. At stations located within Apra Harbor and with depths greater than 60 feet, a modified sampling procedure was utilized to sample only for water-column parameters, sediment contaminants, and benthos. The Guam assessment is designed to be conducted during the island's wet season, July through December, during even numbered years. To conduct the sampling, fisheries experts from the staff of the Government of Guam Department of Agriculture's Division of Aquatic and Wildlife Resources collaborated with staff scientists from the Monitoring Program of the Guam Environmental Protection Agency.



Estuarine and nearshore sampling stations used in the 2004 NCA survey of the island of Guam (U.S. EPA/NCA).

The field sampling for the Guam NCA was initiated in November 2004 and completed in August 2005. High seas proved to be a major challenge to conducting field work in the near-coastal area of Guam because tropical typhoons in the region frequently generated rough weather. Additional difficulties were encountered in the deepest areas of Apra Harbor. In spite of an attempt to use grab samplers in this area, five stations could not be sampled with the vessel available due to excessive depth and strong currents; alternate stations were added as replacements. All of the dropped stations were at depths greater than 120 feet. During the NCA in 2004, 50 stations were successfully sampled (see map). Samples collected during the study period are still undergoing analyses.

The Guam NCA represents a major effort on the part of the Guam Environmental Protection Agency to improve its approach to monitoring the coastal resources of the island. The effort would not have been possible without the collaboration and support of scientists from EPA NCA and the EMAP, the staff of EPA Region 9 Pacific Islands Office, and the dedicated personnel from multiple agencies of the Government of Guam.

Assessment and Advisory Data

Fish Consumption Advisories

Since 1993, American Samoa has had a fish consumption advisory in effect for chromium, copper, DDT, lead, mercury, zinc, and PCBs in Inner Pago Pago Harbor (Figure 8-23). This estuarine advisory recommends that all members of the general population (including sensitive populations of pregnant women, nursing mothers, and children) not consume any fish, fish liver, or shellfish from the waters under advisory. In addition, these same waters are also under a commercial fishing ban that precludes the harvesting of fish or shellfish for sale in commercial markets. Guam, the Northern Mariana Islands, and the U.S. Virgin Islands did not report fish consumption advisory information to EPA in 2003 (U.S. EPA, 2004b).

Beach Advisories and Closures

American Samoa, Guam, the Northern Mariana Islands, and the U.S. Virgin Islands did not report monitoring, advisory, or closing information for any beaches in 2003 (U.S. EPA, 2006c).

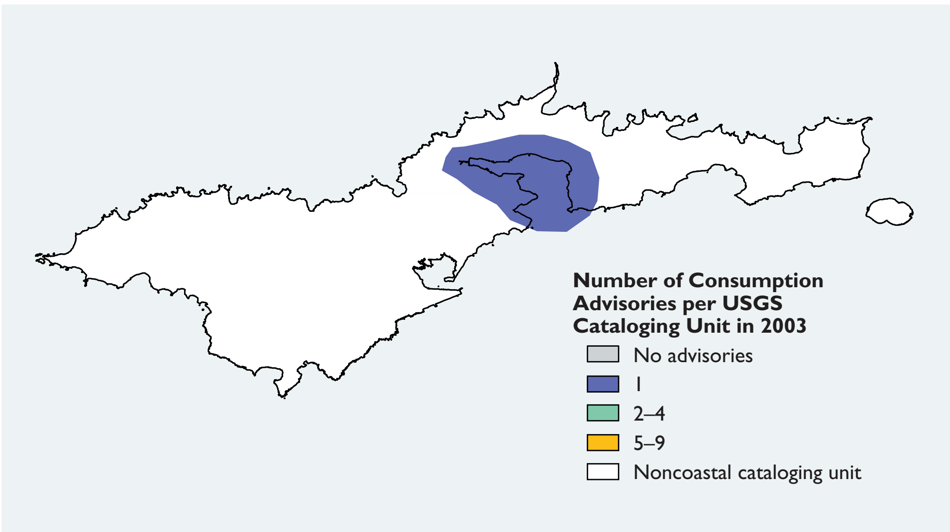


Figure 8-23. Fish consumption advisory for American Samoa, location approximate (U.S. EPA, 2004b).

Pago Pago Harbor, American Samoa (courtesy of NPS).

Summary

During 2002, NCA conducted sampling in the coastal waters of Southcentral Alaska and in Hawaii. Puerto Rico was assessed by NCA in 2000, and those results were presented in the NCCR II and are summarized here. Sampling was conducted in Guam, American Samoa, and the U.S. Virgin Islands in 2004–2005; however, these results are not included in this NCCR III. Currently, no plans have been made to assess the Northern Mariana Islands.

Based on the NCA data, overall condition is rated good for Southcentral Alaska's coastal waters, good in Hawaii's coastal waters, and poor in the coastal waters of Puerto Rico. The water quality, sediment quality, and fish tissue contaminants indices are rated good for Southcentral Alaska. All of the component indicators, except for DIP and water clarity, are also rated good for Southcentral Alaska, and DIP and water clarity are rated fair. The coastal habitat and benthic indices were not assessed for Southcentral Alaska's coastal waters. In Hawaii, the water quality index is rated good and the sediment quality index is rated fair to good. Chlorophyll *a* is the only component indicator rated fair for Hawaii; the rest of the indicators are rated good. The coastal habitat, benthic, and fish tissue contaminants indices were not assessed in Hawaii during 2002. As reported in the NCCR II, Puerto Rico's water quality index is rated fair, and the sediment quality and benthic indices are rated poor. The coastal habitat and fish tissue contaminants indices were not assessed in Puerto Rico. Trends in NCA data could not be evaluated for Alaska, Hawaii, or Puerto Rico.

NOAA's NMFS manages several fisheries in the LMEs bordering Alaska and Hawaii, as well as those in the waters surrounding Guam, the Northern Mariana Islands, and American Samoa. No information is available for the fisheries of LME surrounding the U.S. Virgin Islands and Puerto Rico. The East Bering Sea LME and the Gulf of Alaska LME are two of the LMEs that surround Alaska, and NMFS manages the salmon, herring, demersal fish, and shellfish fisheries in these waters. In general, salmon and crab resources are fully utilized; East Bering Sea LME demersal fish stocks are slightly underutilized; herring and Gulf of Alaska LME demersal fish stocks are relatively stable; and shrimp stocks are low. The Insular Pacific-Hawaiian LME consists of the waters around Hawaii and is managed by the NMFS Western Pacific Region in conjunction with the waters surrounding Guam, the Northern Mariana Islands, and American Samoa. The fisheries managed in these waters include invertebrate, demersal fish, and pelagic armorhead fisheries. The lobster and pelagic armorhead fisheries are closed or under a fishing moratorium; the coral fishery is open, but only shallow-water, black coral is being harvested. Limited stock assessments indicate that MHI spawning stocks of demersal fish are at 5% to 30% of unfished levels.

Summary

Contamination in the coastal waters of Hawaii and American Samoa has affected human uses of these waters. In 2003, there was one fish consumption advisory in effect for Pearl Harbor, HI, and one in effect for Inner Pago Pago Harbor, American Samoa. Hawaii's advisory was for PCBs, and American Samoa's advisory was for chromium, copper, DDT, lead, mercury, zinc, and PCBs. Alaska, Puerto Rico, Guam, the Northern Mariana Islands, and the U.S. Virgin Islands did not report fish consumption advisory information to EPA in 2003. None of these areas reported beach monitoring, advisory, or closure information to EPA for 2003.